THE WEATHER AND CIRCULATION OF MAY 1961

Persistent Cool Weather in the United States

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1. HIGHLIGHTS

The outstanding feature of the weather of May 1961 was the persistence of the cold regime of the preceding month [1] throughout most of the United States east of the Rocky Mountains and also in the Pacific Northwest. In the East numerous stations from St. Louis, Mo., eastward through the Ohio Valley to Youngstown, Ohio reported the coldest average temperatures on record for May. In the Far West unseasonably cold temperatures retarded the maturity of crops through most of the Great Valley of California and below normal temperatures extended into extreme southern California.

A major contribution to the low mean temperatures for May came from an extremely cold polar air mass that blanketed the eastern half of the country during the last week of the month. Beginning on the 26th, record low temperatures were recorded throughout the Middle West and eastward, with frost as far south as Kentucky and snow in Ohio and Michigan. Daily temperature anomalies ranged from more than 20° F. below normal in New England and the Mid-West to 10° F. below normal through the Gulf States during this period.

Extremely heavy precipitation from the Central Plains eastward through the Ohio Valley resulted in major floods throughout the month in most of the Arkansas, Missouri, Ohio, and Middle Mississippi River watersheds where amounts ranged from more than 8 inches at Concordia, Kans. to a record 12.22 inches at Evansville, Ind. On the other hand, drought conditions that prevailed in April 1961 through the Southwest from Texas to southern California continued during May except in extreme western Texas. There was no measurable precipitation in the extreme Southwest or at Corpus Christi, Tex., a new record for May at that station.

2. THE GENERAL CIRCULATION

The general circulation for May 1961 at 700 mb. (fig. 1) does not show many unusual features in spite of the extremely anomalous weather observed over most of the United States. Blocking, which had dominated eastern Canada during April [1] and the northeastern Atlantic during March [2], retrograded rapidly to the Alaskan area where mean height anomalies increased 210 ft. from April (fig. 2). At the same time height anomalies decreased by 570 ft. near Baffin Island, representing a rather abrupt return to normal in that area.

In the Southwest Pacific filling of the deep Asiatic coastal trough observed in April and intensification of the subtropical High downstream were predominantly climatological as shown by the small anomalous changes (fig. 2). However, this normal change, concurrent with deepening east of Kamchatka and blocking to the north, produced a zone of confluence south of Kamchatka which was the dominant feature of the circulation. Figure 3 shows that the maximum mean 700-mb. westerlies in this region were from 4° to 5° of latitude north of their normal position (A) and 9 meters per second faster than normal (B). Downstream, the effects of blocking on this high-index Pacific circulation are shown by a diminution of wind speeds in the broad difluent area of western North America and by the southward displacement (from normal) of the 700-mb. jet stream through the extreme southwestern United States.

Elsewhere the anomalies of the general circulation were within 160 ft. of the long-period normal, the largest month-to-month changes (fig. 2) being indicative of a return to normal from the more anomalous state of April [1].

3. TEMPERATURE

The cool temperature regime of April continued through May with nearly all of the contiguous United States averaging below normal except Texas and the Rocky Mountain States (fig. 4). In much of the Mid-West and Ohio Valley the persistent low temperatures of April and May 1961 combined to make this period the coldest since 1907. The cool regime in the Pacific States and the Great Basin, while not of record intensity, was extremely persistent, particularly in the Great Valley of southern California. The number of days in the month during which the average daily temperature exceeded the normal ranged from only six at Sacramento to four at San Diego. Santa Maria recorded only one day above normal and that by only 1° F.

The unusual month-to-month persistence of temperature

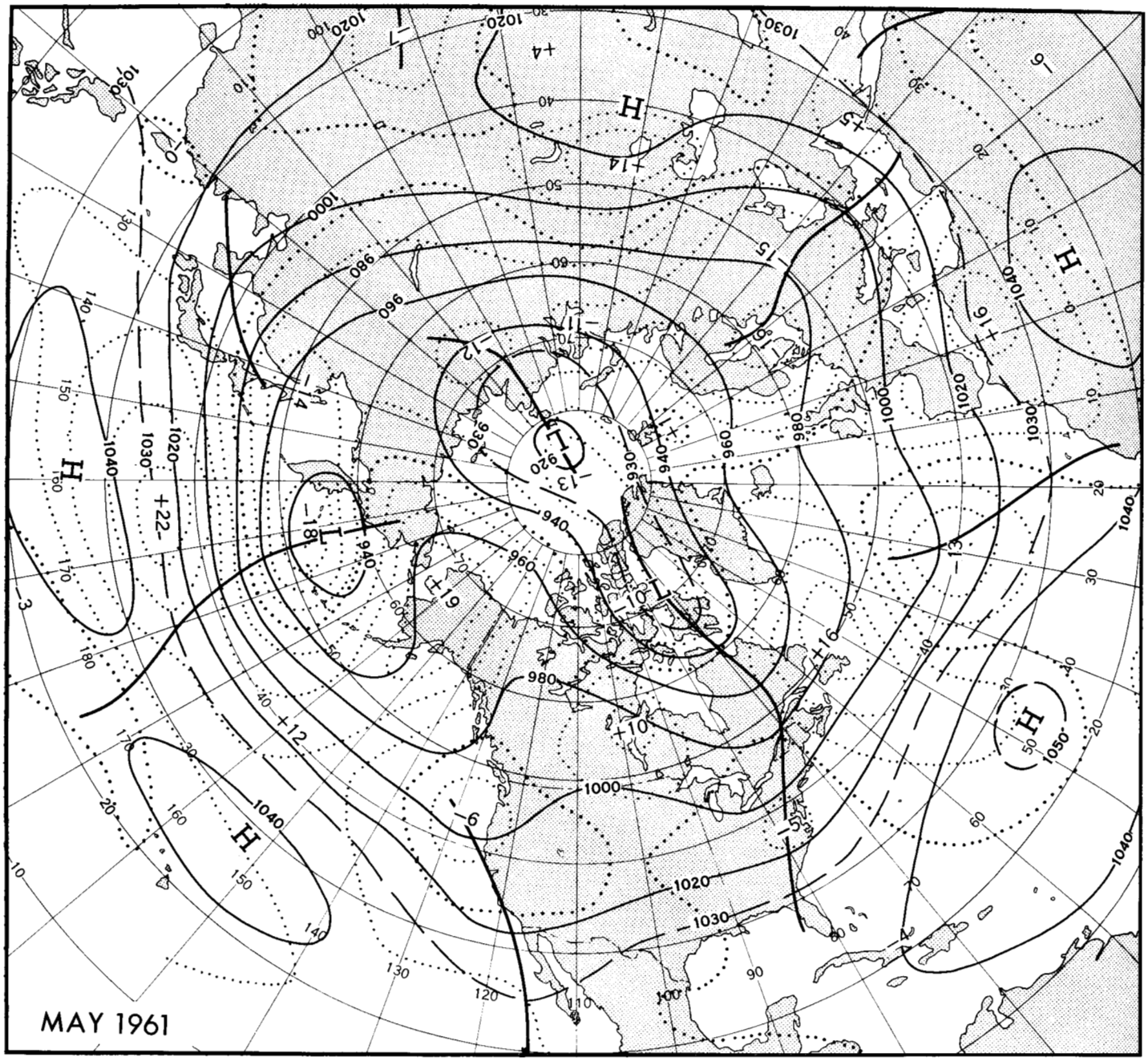

FIGURE 1.—Mean 700-mb. contours (solid) and height departures from normal (dotted) (both in tens of feet) for May 1961. Above normal heights in Canada and Alaska were associated with frequent anticyclogenesis and cool weather east of the Rocky Mountains.

is well illustrated by figure 5, the change in temperature anomaly class (out of five classes) from April to May. In a distribution of 100 cities, 37 remained in exactly the same class as the previous month, covering the area shown by crosshatching. No city changed by as many as 3 or 4 classes, and 79 changed by no more than 1 class. The latter figure compares with 59 expected by chance, 32 observed from March to April 1961 [1], and 62 for the average April–May change from 1942 to 1957 [4].

Although the pattern of temperature anomaly follows closely the negative height anomaly at 700 mb. the relative magnitude of the temperature anomaly was much greater than that of the height anomaly. Examination of the 15-day components of the monthly 700-mb. height mean, figure 6, shows a two-fold effect operating to maintain cool temperatures in the Far West. During the first half of the month low temperatures were associated with anomalous northerly flow from a blocking High centered over Alaska (fig. 6A), and with the main westerlies displaced well south of 40° N. During the latter half of the

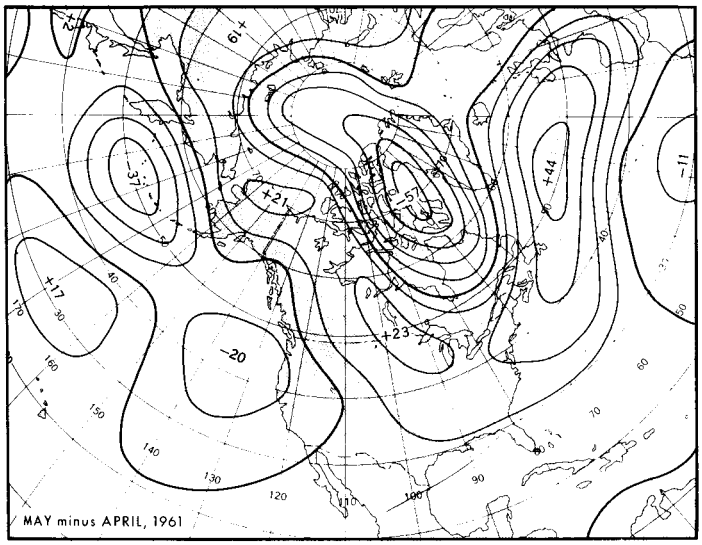

FIGURE 2.—Change in 700-mb. height anomalies (tens of feet) from April 1961 to May 1961. Relaxation of blocking in eastern Canada is represented by the largest change area.

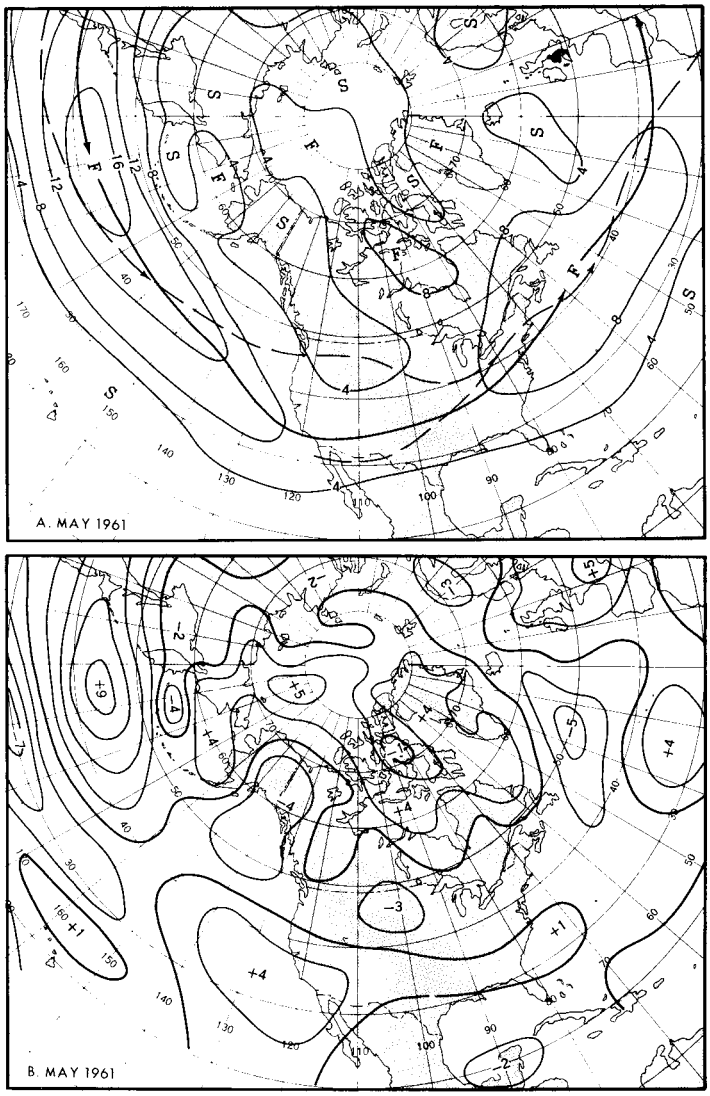

FIGURE 3.—(A) Mean 700-mb. isotachs and (B) departure from normal wind speed (both in meters per second) for May 1961. Solid arrows in (A) indicate primary axes of the westerly jet stream, and dashed arrows indicate their normal May positions. The westerlies were displaced well south of the normal position over western United States, and an important secondary maximum was located over northeastern Canada.

month temperatures modified considerably in the Northwest (fig. 8 C, E) as the blocking over Alaska relaxed (fig. 7), and the circulation returned to the dominant spring pattern of troughs near the east and west coasts and a strong full-latitude ridge through mid-continent (fig. 6B). The extreme negative tilt (northwest to southeast) of the west coast trough is commonly associated with the southward displacement of mid-latitude westerlies and helped maintain cool temperatures in southern California.

In contrast to the persistent temperature regime of the Far West, temperatures east of the Continental Divide, although predominantly below normal, showed more variability (fig. 8). This variability can be related to the differences in the 700-mb. bimonthly circulations (fig. 7).

During the first half of the month most of the United States was dominated by a broad cyclonic circulation augmented by strong northerly flow in western Canada associated with a blocking High over Alaska. Following an initial outbreak of cold air which affected most of the country except the Gulf States, succeeding polar air masses followed a more northerly track with a warming trend east of the trough in central United States. The track of the "glancing Highs" associated with these shallow polar outbreaks is shown in figure 9A by the arrows through the Great Lakes and eastern Canada. Examination of the 5-day mean charts shows a transition period near mid-month during which the maximum-curvature trough in central Canada joined with the shallow trough in the Northern Plains (fig. 6A) to form a full-latitude trough near the east coast, and the blocking High over Alaska moved east to form a full-latitude ridge just east of the Continental Divide (fig. 6B). Associated with the development of this large-amplitude trough and ridge system was rapid warming throughout the mountain area of western North America (fig. 8G). A succession of cold polar anticyclones moved into the eastern half of the country, as shown by the southernmost track in figure 9A, resulting in frost and light snow in the Mid-West and record low minimum temperatures throughout the East.

4. PRECIPITATION

Of particular interest is the unusually heavy precipitation which occurred in the Central Plains and Middle Mississippi watershed and resulted in floods throughout the area most of the month (fig. 10). Heaviest rains fell during the first half of the month (fig. 8 B, D) associated

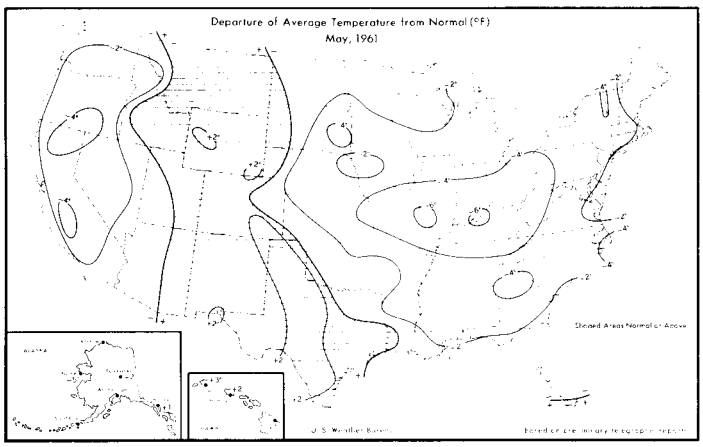

FIGURE 4.—Departure of average surface temperature (° F.) from normal for May 1961. (From [3].) Temperature averaged above normal (shaded) in the Rocky Mountain area but below normal in the remainder of the nation.

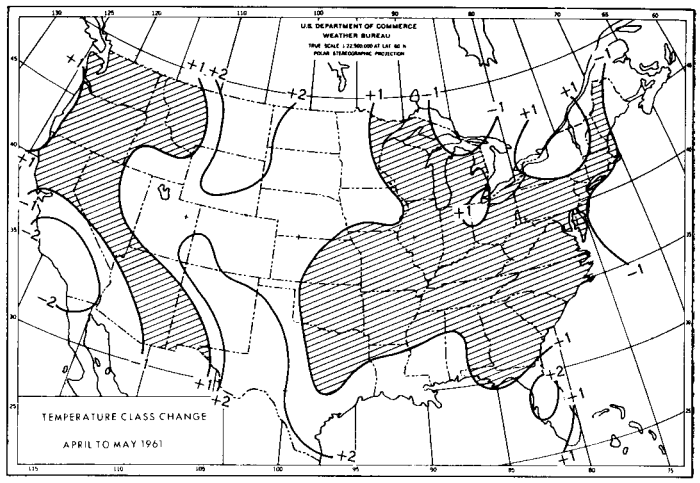

FIGURE 5.—The number of classes (out of five) the surface temperature anomaly changed from April to May 1961. The hatched area represents the area of no change.

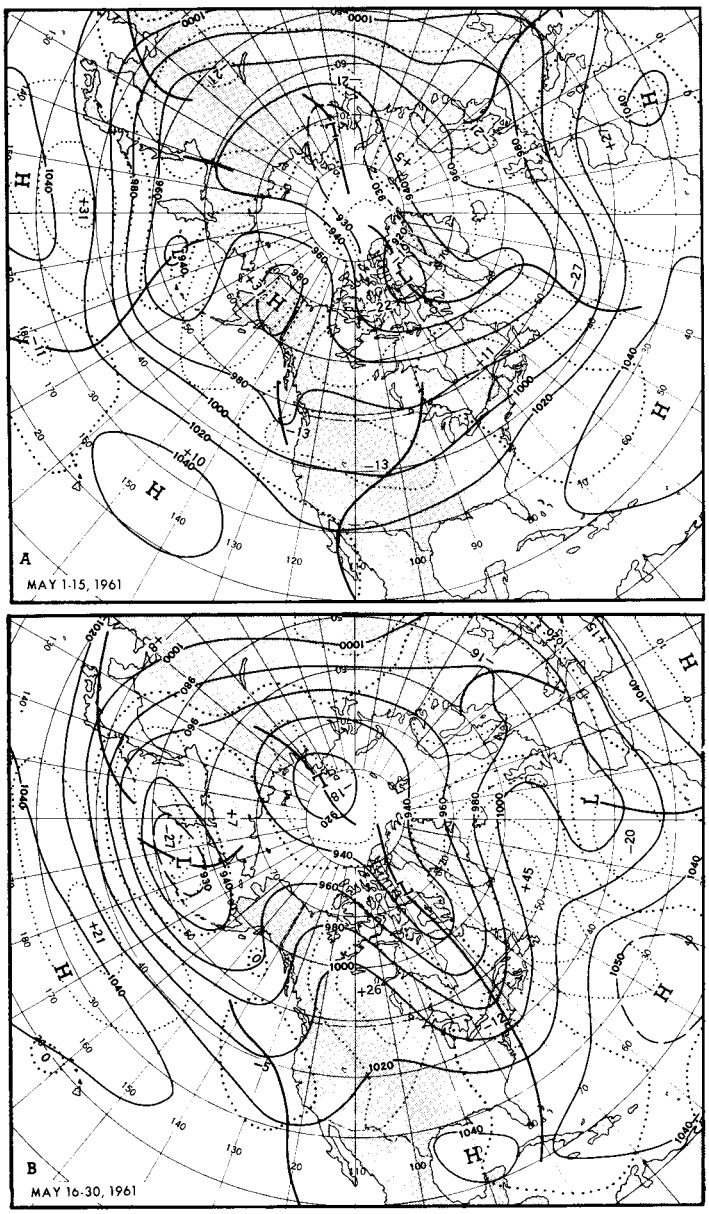

FIGURE 6.—Fifteen-day mean 700-mb. height contours and departures from normal (both in tens of feet) for (A) May 1–15, 1961. and (B) May 16–30, 1961.

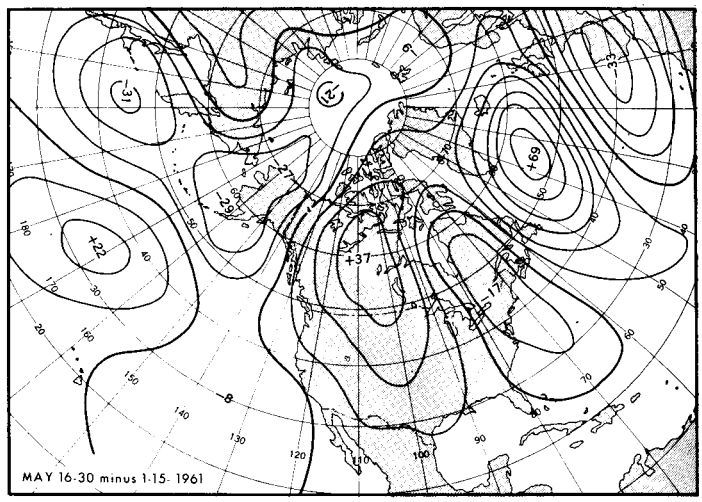

FIGURE 7.—Change in 15-day mean 700-mb. height anomaly from May 1–15 to May 16–30, 1961, in tens of feet. Large intramonthly changes occurred over most of North America except the west coast of United States.

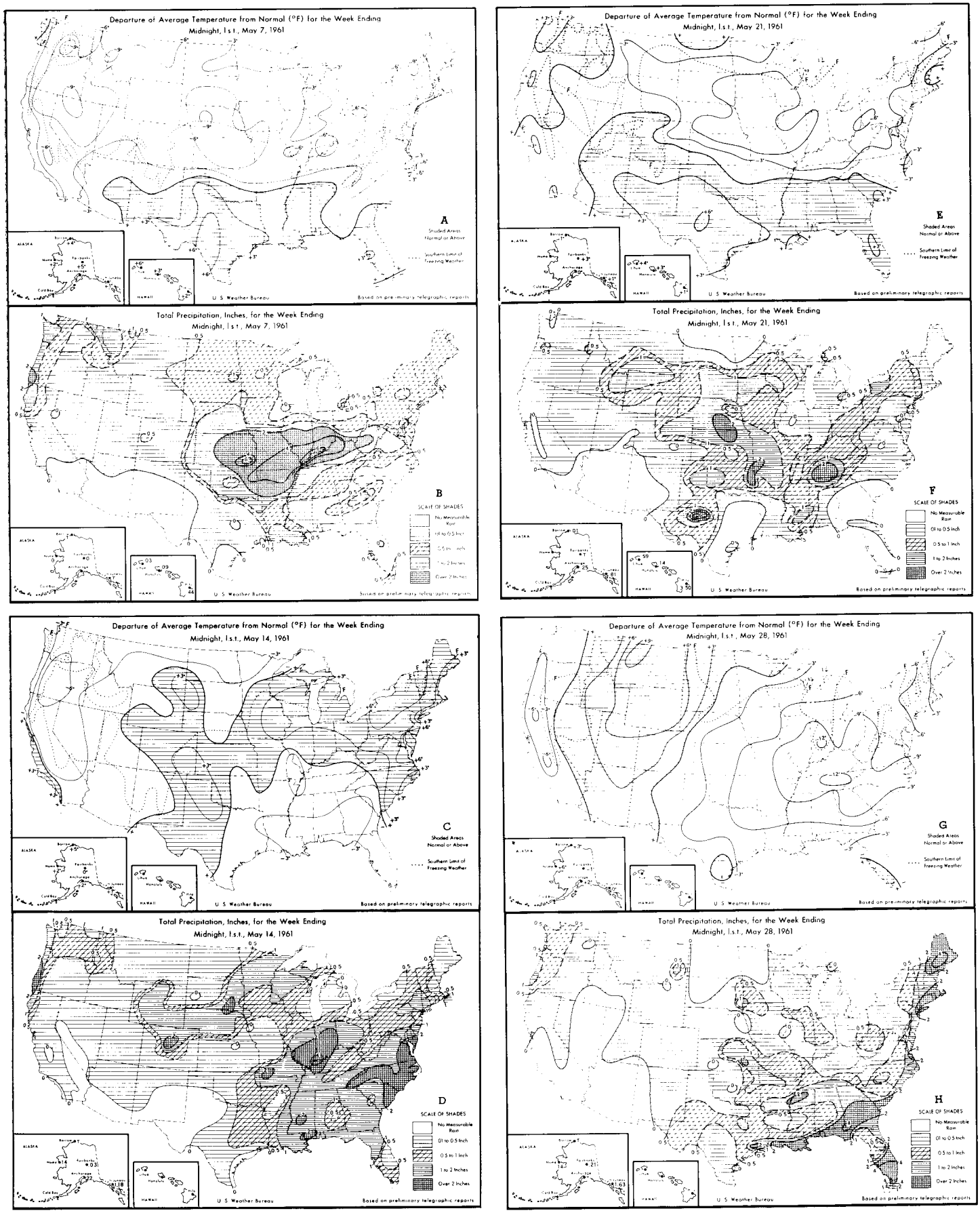

FIGURE 8.—Departure of average surface temperaure from normal (° F.) and total precipitation (inches) for the weekly periods ending (A,B) May 7, (C,D) May 14, (E,F) May 21, and (G,H) May 28, 1961. (From [6].)

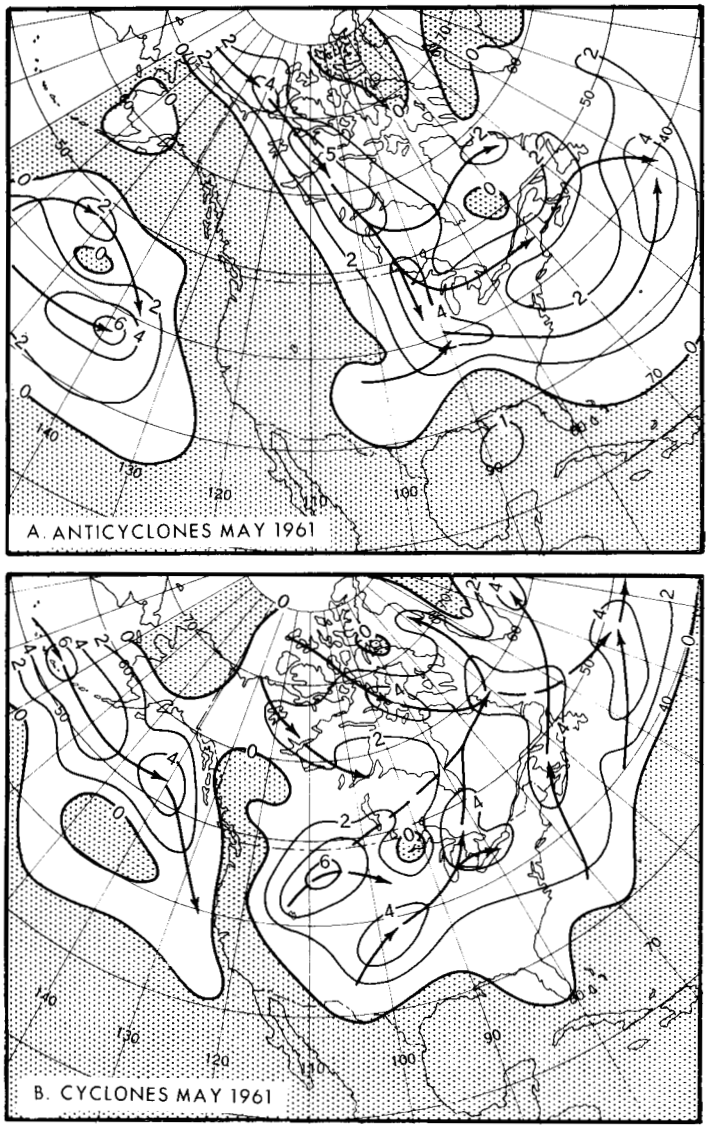

FIGURE 9.—Frequency of (A) anticyclone and (B) cyclone passages (within 5° squares at 45° N.) during May 1961. Primary tracks are indicated by solid arrows, secondary tracks by dashed arrows. Frequent weak Lows in the Northern Plains were of secondary importance compared to major storm development in Central Plains.

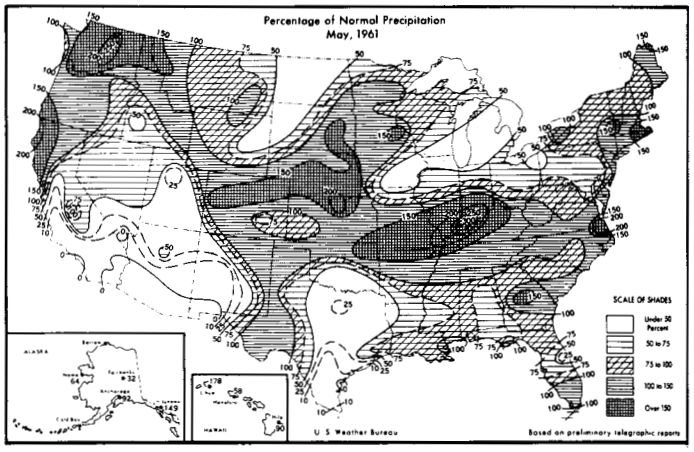

FIGURE 10.—Percentage of normal percipitation for May 1961. (From [3].) No measurable precipitation in parts of the Southwest contrasted with above normal amounts in many other areas.

with the shallow trough through the Plains States and the depressed axis of prevailing westerlies. The effect of the depressed westerlies in restricting the northward intrusion of Gulf moisture is shown indirectly in the frequency and prevailing tracks of daily cyclones for the month (fig. 9B). Although a maximum number of closed Lows was observed in the northwestern Plains, few developed into well organized cyclonic systems, while the major developments occurred just north of the prevailing westerlies in the Central Plains. An interesting effect of the northward limit of Gulf moisture was the range of precipitation through Indiana from a record 12.22 inches at Evansville in the south to only 1.19 inches at South Bend in the north, the dryest there since 1939. Such sharp gradients are frequently associated with marked confluence of the mean 700-mb. contours, such as prevailed over Indiana this month (fig. 1). Precipitation was normal to above normal in the Pacific Northwest under the influence of the weak coastal trough despite the weakness (relative to normal) of the westerlies at mid-latitudes.

During the week ending May 15, a major storm moved out of the lower Mississippi Valley and produced moderate to heavy precipitation over most of the eastern half of the country. Intense deepening of the parent storm as it moved into eastern Canada resulted in a fresh polar outbreak of cold air reaching to the Gulf States, and a rather intense wave developed in response to the sharp temperature gradient near northern Florida. However, a sudden northward shift of the jet stream in response to the deep cyclonic vortex near Hudson Bay and anticyclogenesis to the south over the Great Lakes resulted in cutting off the wave near Florida from the main westerlies. The major portion of the month's precipitation in the coastal area of South Carolina to Virginia was produced by the slow northward migration of this cut-off coastal Low from May 10 to May 13.

Heaviest precipitation in the Northeast occurred late in the month in conjunction with wave development as a cold front moved off the Middle Atlantic coast in advance of the extremely cold polar air mass mentioned earlier. Subsequent baroclinic deepening in the mean east coast trough resulted in precipitation amounts in excess of 4 inches in parts of New England (fig. 8H).

As is often the case, precipitation, or the lack of it, is difficult to specify. In the Southwest it seems likely that the strong low-latitude westerlies operated to produce a rain shadow effect and to prevent moisture from being introduced by large-scale southeasterly components of the general circulation. More difficult to explain is the continued drought in eastern Texas. Here lack of moisture at high levels and anticyclonic vorticity just south of the jet stream limited precipitation to scattered showers

through most of the period. During the latter half of the month a strong easterly flow at low levels associated with a series of large polar anticyclones moving along the southern track of figure 9A resulted in a considerable amount of up-slope precipitation in western Texas. An interesting note on the discontinuous nature of precipitation is the difference between the monthly totals at Houston, Tex. of 0.63 inches at the city office and 3.59 inches at the Airport Station.

In an effort to specify more clearly the month's precipitation, a study was made of the 600-mb. vertical motion charts as computed twice daily from the baroclinic model currently used by the Numerical Weather Prediction Branch (NWP). Values were read at 5° intervals of latitude and longitude, and charts were constructed of weekly mean values and mean positive values only for periods corresponding to those in figure 8, and mean values and mean positive values only for the period corresponding to figure 10. The results show little correspondence between the observed precipitation patterns and the patterns of *mean* values of vertical motion on either a weekly or a monthly basis. On the other hand, the patterns of *positive* values only show a fair correspondence with the observed precipitation in some areas. However, there are many inconsistencies; e.g., the dry areas of Texas and the Great Lakes show definite maxima in several cases, and the heavy rains in the Ohio Valley and New England lie in areas of minimum vertical motion in others. This would indicate that other parameters such as available moisture, warm air advection, thickness advection, the extent of over-running of a cold stable air mass, etc., should be included in any specification scheme. Unfortunately the measurement and data processing of these parameters is not as easy as for vertical motion.

This experiment is similar to that done by Woffinden [5], and was repeated only because of the difference in the circulation and weather regime. However, the general results and conclusions are the same.

REFERENCES

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